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INTERACTIVE OBJECT-ORIENTED DISPLAY TECHNOLOGIES: A STUDY OF TWO CD-ROM-BASED DMA PRODUCTS

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September 1992

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This integration of standardized full color maps into technical reports and computer software has been a complex and time consuming process. This work reports on the use of two readily available Defense Mapping Agency ARC Digitized Raster Graphics (ADRG) and Digital Chart of the World (DCW) product lines that can greatly facilitate this process. The report includes samples of these maps and includes as an addendum several computer disks for use with these products.

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INTERACTIVE OBJECT-ORIENTED DISPLAY TECHNOLOGIES: A STUDY OF TWO CD-ROM-BASED DMA PRODUCTS

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PREFACE

This study investigates the possibility and process of utilizing Defense Mapping Agency CD-ROM based map products as a standard method for the generation and reproduction of maps in both IDA hardcopy publications and software. The conceptual driver for this effort is the fact that it is often difficult to quickly obtain presentation quality maps that may be utilized in a consistent and standardized fashion in both printed and computer software products. The utilization of readily available standardized sets of worldwide map databases and software which can be acquired from DMA can significantly reduce the time required to obtain maps and can result in a high quality consistent "look and feel" in the products that utilize them. Over a period of time this consistency can potentially lead to more easily understood publications and software products. This study specifically focused upon utilization of the DMA ARC Digitized Raster Graphics (ADRG) and Digital Chart Of The World (DCW) map product lines.

Acknowledgments

The authors thank the reviewers of this document Mr. Edward Kerlin and Mr. Chris Christenson. Our discussions with them, their well pointed comments, and timely review are much appreciated.

The Defense Mapping Agency Systems Center provided us with considerable assistance during this study. In particular we extend thanks to CDR Don Potter who helped us with the ADRG products, and to LTC Paul Foley who graciously allowed us to experiment with the beta release of the DCW product and who subsequently provided us with access to the full DCW product release. This study could not have been accomplished in a timely fashion without your help.

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ACRONYMS

ADRG	ARC Digitized Raster Graphics
BMP	Microsoft Windows Bitmap File Format
CD-ROM	Compact Disk-Read Only Memory
DDE	Dynamic Data Exchange
DCW	Digital Chart Of The World
DMA	United States Defense Mapping Agency
JNC	Jet Navigation Chart
JOG-A	Joint Operations Ground-Air
IDA	Institute For Defense Analyses
ISO	Industrial Standards Organization
ONC	Operational Navigation Chart
PCX	Common Paint Program File Format
RGB	Red Green Blue
TLM	Tactical Line Map
WGS 84	WORLD GEODETIC SYSTEM 1984

CRP 9000 -649
Interactive Object Oriented Display Technologies
A Study Of Two CD-ROM Based DMA Products

BACKGROUND

In our initial proposal funding was requested for the development of an object oriented graphic user interface to the proposed "TacFlo" computer simulation. This project intended to develop a rapid prototype visual display system for "TacFlo". This prototype was to incorporate CD-ROM based Defense Mapping Agency (DMA) maps of the world. The "TacFlo" simulation concept has been overcome by events, but the need for a systematic and transferable access to DMA's maps in IDA PC based software products remains.

The scope of this task therefore reflects this generalized need. Subsequent investigation of the availability of DMA CD-ROM mapping products for the desktop PC revealed at least two products that were of general interest to IDA. This investigation has since focused upon two DMA standard products — the raster based ARC Digitized Raster Graphics (ADRG) and the vector based Digital Chart of The World (DCW) CD-ROMs. This paper will present the results of this investigation and includes as an addendum the public domain software code acquired/adapted and some rapid prototype software developed to assist in IDA use of these products. It should be noted that the DCW product is new and was not available until just before the end our study. Our investigation dealt primarily with the Beta release of the DCW product and its public domain access software. However, DMA, graciously provided us with a full 4 CD-ROM release of this product at the end of August and we have included sample map outputs from it here.

INTRODUCTION

The Defense Mapping Agency utilizes CD-ROMs to distribute a variety of mapping products. These products fall into two basic categories: 1) digitized raster scans[1]

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[1] A digitized raster scan can be pictured as a two dimensional matrix of points in space. Each of these points has a specified color or intensity value and is at some fixed distance from its horizontal and vertical neighbors in the matrix. This distance is the resolution of the matrix or map.

and 2) digitized vector scans of maps[2]. In general terms digitized maps are large databases that represent the content of the original map. The database table structure that is chosen for these large map databases is largely responsible for the type of map that can be regenerated from the database. The importance of this can not be overstated because it is possible to lose information that is contained in the original map if the database table design and/or the database tables are recorded in a manner that fails to sufficiently represent the detail of the original. This is not easily accomplished because the original maps often contain a tremendous amount of standardized information.

Both the ADRG and DCW maps adhere to the WGS 84 standards and are often derived from the lithographic plates that were used to generate hard copy maps that follow these same standards. The database size of a single map sheet digitized in color at standard reproduction resolutions is hundreds of megabytes. This size is impractical for use on most machines, but the availability of low cost and highly reliable CD-ROM storage devices and disks has overcome this problem.

The utilization of CD-ROMs as distribution media for large size databases is now a standard practice. CD-ROMs can hold as much as 650 MB of read only information and are both durable and inexpensive to produce. In quantities of 1000 or more their mastering and duplication costs are less than $3.00 per CD-ROM copy. CD-ROMs can also be easily numbered during production which facilitates the distribution and tracking of the copies. DMA has found CD-ROM technology to be the media of choice for most of its current map database products.

METHODOLOGY

The approach taken for this work was to first identify DMA mapping products that we believed had the most potential for general use at IDA. Once identified, the military standards and any references that were necessary for our understanding of these products, or software related to them, were obtained and reviewed. After this review the actual products were obtained, installed, and experimented with and/or tested.

The ADRG product line was identified as a general interest mapping resource for IDA. Several staff members have used this product in support of IDA task work but none had been able to use it in IDA developed software products because of the complex nature

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[2]A digitized vector scan can be thought of as a series of lines and polygons that define spatial features. The lines and polygons are composed of a number of points that are sufficient to resolve the shape of the specific feature they correspond with to some given resolution.

of the computer code that is required to access it from the CD-ROM distribution media. During the course of this study discussions with DMA personnel revealed the existence of public domain software that could display the contents of the ADRG products. This software was located, permission to release it to IDA was obtained, and the software was delivered, installed, and experimented with.

As a result of this work and subsequent discussions with DMA we identified a second mapping product known as the DCW. We tested and experimented with a Beta release of the new DCW product and its VPFVIEW display software. This new set of map databases and software encompasses the entire world at ONC resolution on four CD-ROMs. The commercial release of this product is now available.

A summary of our findings is shown below for both the ADRG and DCW product lines.

ARC DIGITIZED RASTER GRAPHICS

Raster scan products such as the ADRG CD-ROMs contain files which are 24 bit RGB 100 micron resolution (254 DPI) bitmaps of the original maps or charts they were derived from. These bitmap database files are organized into 128 by 128 pixel tiles that can be linked to a geocode system that allows one to determine the latitude and longitude of each raster image point. The actual map resolution of ADRG map products varies widely from JNC (1:2,000,000) to TLM (1:50,000) and not all areas of the earth are covered at all resolutions. The number of available ADRG CD-ROMs numbers in the hundreds and they may be ordered as standard DMA products. Security restrictions do apply to certain products and the individual CD-ROMs are color coded as described in Military Specification MIL-A-89007 which is the primary reference document for the ADRG product line.

ADRG Public Domain Computer Software

ADRG CD-ROMs follow the ISO 9660 standards for volume and file structure. This format is supported by the Microsoft CD-ROM extensions to Microsoft Windows and also by the Apple operating system for the Macintosh. During the course of the development of the ADRG product line DMA developed computer software for both the Apple Macintosh and IBM-PC that facilitated both quality control and evaluation of these products by the DMA development team. This software has been obtained from DMA and has been included on two 3.5 inch disks, one for each system, as an attachment to this

product. These disks contain executable versions of the programs, the program source code, and some limited program documentation. The software can display ADRG maps in full color and has the ability to display map locations and calculate distances between two points on a map display. The MS Windows version of this software has been extensively experimented with during the course of this study.

The windows version of the ADRG software features two types of map displays—an overview map and detailed maps. The overview map shown below allows the user to see the entire geographical area covered by the CD-ROM's detailed maps on a single display screen. The user can then request the software to display a detailed map of a user selected area on the overview map. These detailed maps can be viewed at resolutions of 1:8 to 8:1 relative to their original scale. We have included several examples of these maps below. The map images are from the geographic area of Kuwait and show much of the area in which Operations Desert Shield and Desert Storm took place.

The ADRG program will allow users to save screen images to disk in the Windows bitmap format (.BMP) but will not allow the direct printing of ADRG screens. The color samples included in this document were printed on an HP Paint Jet XL printer via the Publishers Paint Brush software package and MS Word for Windows version 2.0. The images were opened into Publishers Paint Brush and cut into the Word document via the Windows Clipboard. All of the original images were 256 color VGA screen displays.

It should be emphasized that this software is quite complex and the entire source code listing for this program is some 200 plus pages in length.

ADRG maps are a potentially valuable map resource for commercial products. Hyperdyne Corporation, the maker of MAPIX, a commercial mapping package, has produced an IBM computer program called ADRG2PCX that will convert ADRG CD-ROM based maps into PCX files. This program will also create PCX based mapsets for the MAPIX package that retains the ADRG geocoding information They have placed a version of this product in the public domain and it may be obtained directly from Hyperdyne.

MAPIX: A Commercial Mapping Package

Recognizing the fact that the use of commercial mapping products is not always precluded by study and/or distribution requirements we experimented with Hyperdyne Inc. MAPIX software. MAPIX is one of several PC mapping products that are available but it is the only one known to be compatible with the DMA ADRG CD-ROM map databases.

MAPIX is a robust raster based commercial mapping package that is available for Microsoft Windows. The package utilizes tile based Map-sets that are geocoded and in the PCX format. MAPIX maps may be derived from many sources including ADRG CD-ROMs, PCX images, and scans of hard copy. The program supports geocoding of scanned images. This geocoding support includes everything from simple linear interpolation based upon two user specified reference points to complex geocoding based upon a wide variety of user selected projections and reference points. MAPIX supports the MS Windows Dynamic Data Exchange (DDE) standard and is capable of interacting with other Windows applications supporting this standard. A sample MS-Excel macro that demonstrates this DDE capability is provided with the product. MAPIX can display routes and symbols on its maps and it can monitor a file that contains this information and automatically update their display as the files contents change. MAPIX provides a robust set of features that can support the creation of fairly complex geographic information systems in conjunction with other Windows compatible products.

ADRG EXPERMENTAL RESULTS

The map shown in figure one below is an overview map taken from the JNC 35 CD-ROM. Notice that this map only provides a general indication of the area that is being investigated; much of the detail has been lost in the lettering and other map features. Even so this map allows the user to readily select an area for more detailed study.

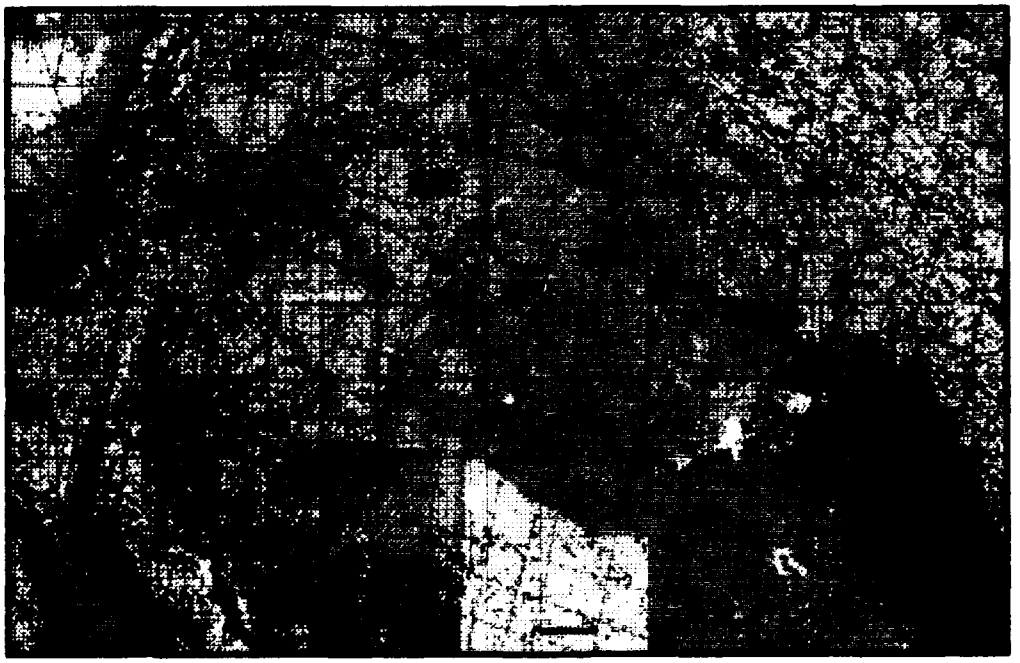

Figure 1. JNC 35 CD-ROM Overview Map

The map shown in figure 2 below represents a 1:2 representation of the detail that can be seen on JNC (1:2,000,000) ADRG maps. A 1:1 portion of this same JNC map is shown in figure 3 and a 1:1 section of this area from an ONC (1:1,000,000) map is shown in figure 4. The detail that is depicted in these maps compares favorably with the original charts that they were derived from. The ADRG maps permit even finer resolution than shown here and figure 5 shows an overview map taken from an ADRG JOG-A scale (1:250,000) CD-ROM of this area and figure six illustrates the street level details that can be seen for a part of Kuwait City while figure seven shows an area around Kuwait International Airport. As a final example of the ADRG product I have enclosed a 1:2 enlargement of a JOG-A detailed map in figure 8 to show the type of detail that one can expect from the same type of filtering that was done for figure 2.

Figure 2. JNC 35 Detailed Map at 1:2 Display Resolution

Figure 3. JNC 35 Detailed Map At Full Resolution 1:1

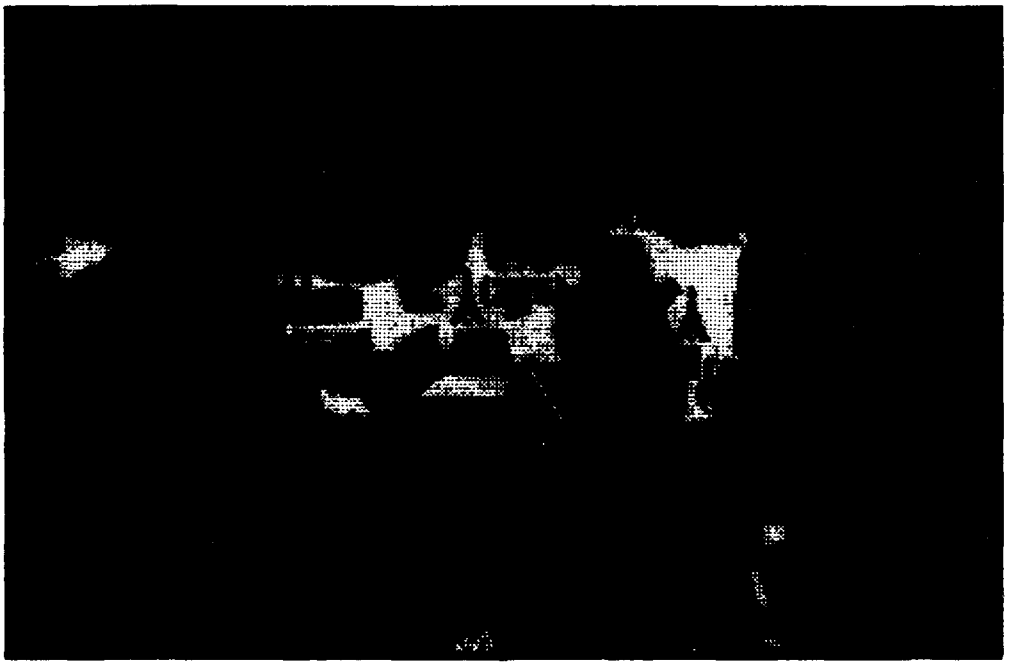

Figure 4. ONC H-6 Detailed Map At Full Resolution 1:1

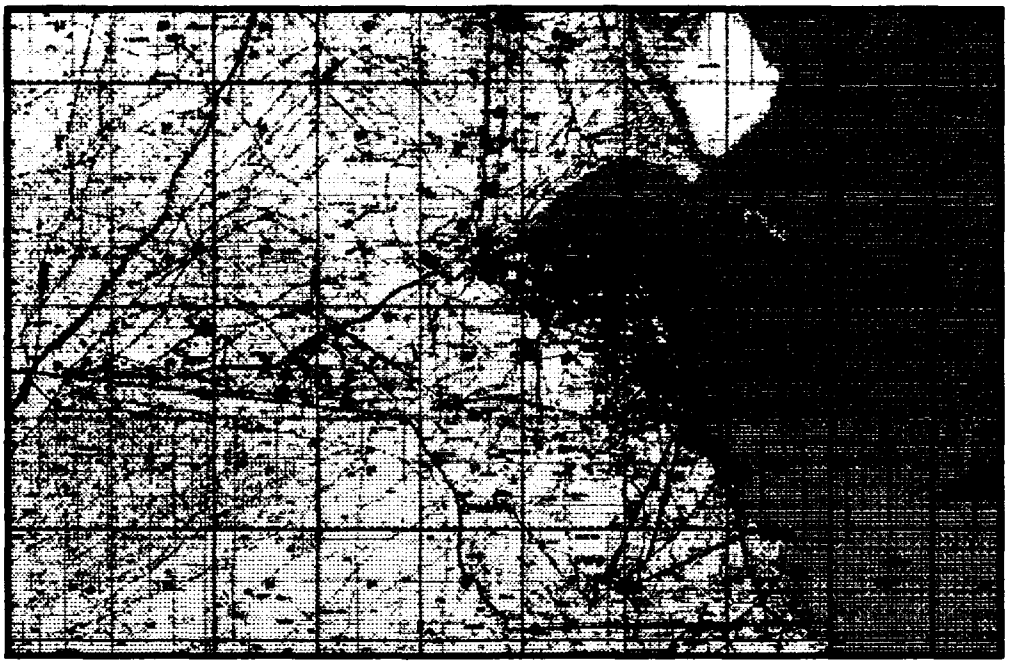

Figure 5. JOG-A NH 38-12, -16; NH 39-9, -13 Overview Map

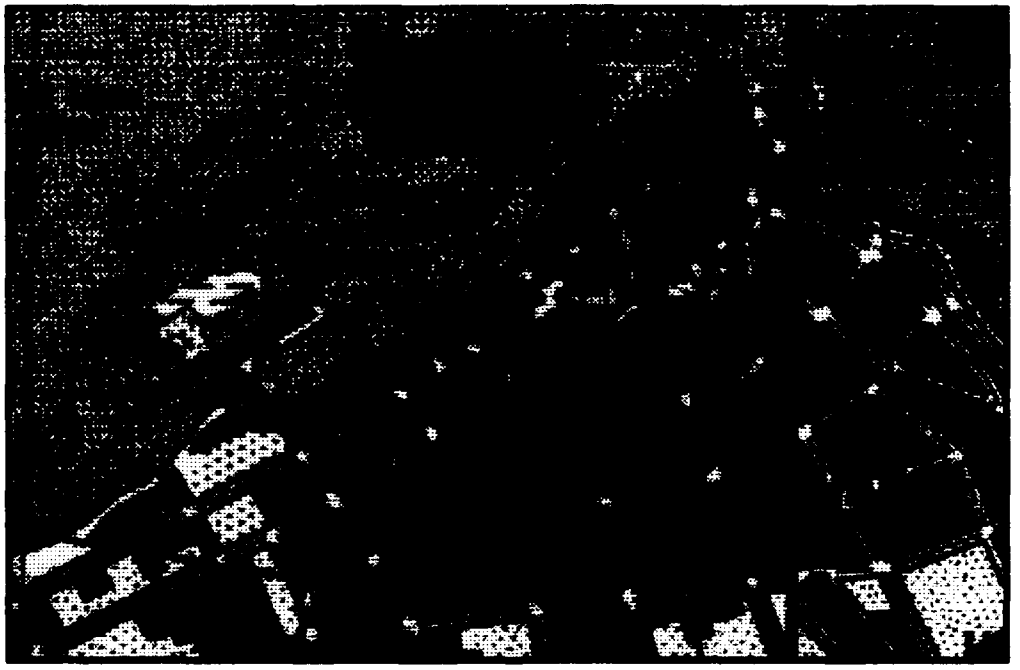

Figure 6. JOG-A NH-38-12, -16; NH 39-9, -13 Full Resolution Street Map Of A Section Of Kuwait City

Figure 7. JOG-A NH-38-12, -16; NH 39-9, -13 Full Resolution Area Around Kuwait International Airport

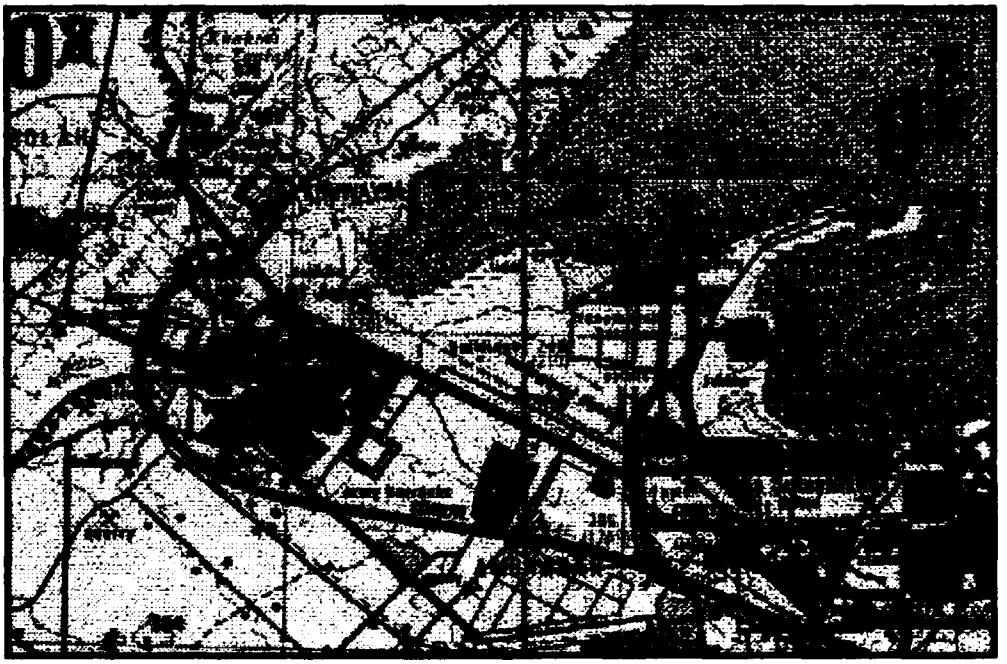

Figure 8. JOG-A NH-38-12, -16; NH 39-9, -13 1:2 Resolution Of Al Kuwait Bay Area

DIGITAL CHART OF THE WORLD

The vector scan product known as DCW has just been released and contains ONC (1:1,000,000) and JNC (1:2,000,000) resolution vector maps of the world on four CD-ROMs. Each of these four CD-ROMs additionally contains a copy of the BROWSE world overview library (1:32,000,000) and one of the four detailed libraries. NOAMER disk covers North America, EURNASIA covers Europe and Northern Asia, SOAMAFR covers South America and Africa, and SASAUS covers Southern Asia and Australia. What distinguishes the DCW product from ADRG and other products is its separate map feature database tables that facilitate the display of as few or as many of the available features as the user desires. Thus the DCW product facilitates the construction of layered maps which can be very difficult to do with the raster map products. The VPFVIEW Users Manual provides a good description of the available features that may be plotted on DCW maps and also provides the database keys necessary for their extraction.

The DCW database tables follow the Vector Product Format, Military Standard 600006 and are arranged around the 15 by 15 degree GEOREF Tiling System. These tiles are further subdivided into 5 by 5 degree database tables as specified in Military Specification MIL-D-89009 Digital Chart Of The World. This organization facilitates both the data extraction speed and the archiving of data to media other than CD-ROM.

DCW EXPERIMENTAL RESULTS

The VPFVIEW Software Package

The VPFVIEW software is a public domain software package that is included in both executable and source code form with the DCW product. The software utilizes the Borland Graphics Interface and can be compiled using either version 2 of the C language or version 3 C++ products. VPFVIEW is a DOS product that could be converted to the MS Windows environment using the C++ product but it is only available for DOS at this time. This software is included as an addendum to this document on 3.5 inch disks. Operational use of this software requires either the DCW CD-ROMs or data extracted from them. For programmers who want to incorporate DCW data access into their programs the source code for VPFVIEW is included. The data access routines are fairly generic and should be generally useful even for those who don't want to use the Borland graphics display routines.

The product supports the generation of Post Script output files for printer hard

copy and PCX bitmap screen files. We found the PCX files to be fully compatible with our software packages. However, the PostScript files that were generated by VPFVIEW often failed to print on our fully PostScript compatible printers. Investigations into the cause of this proved fruitless and we suspect the problem lies in the lack of something in the files header information. It should be noted that small unsophisticated files printed but more complex files generally would not print even on PostScript printers with 10MB of RAM.

The VPFVIEW software can export the DCW databases to other storage media. This can be particularly useful when one wants to speed the use of the DCW database tables. Performance increases of 50 to 1 can be obtained with high speed hard disks relative to the CD-ROM player.

The philosophy behind the VPFVIEW generation of maps from the DCW databases involves the use of themes or topical areas of interest. The DCW database tables encompass some 17 themes[3] and each of these themes is further subdivided into specific features of interest. Examples of themes are Political/Oceans and Roads. An example of features within each of these themes are coastlines and dual lane highways respectively.

When a user generates a map using the VPFVIEW software a set of themes must be selected or specified for display. A set of themes associated for a specific map display is called a Feature Selection List. This list may be saved as a file for generating maps with similar features at other times. The VPFVIEW software comes with several default map views which contain specific feature selection lists. These default views and feature selection lists serve as a good starting point from which the user may generate customized maps which are most suited to the type of study that is being performed.

Below we have provided three increasingly more complex examples of maps that can be generated from the DCW and the VPFVIEW software. It should be noted that these are relatively simple examples and should not be construed as the most complex maps that can be generated from DCW. Figure 9 is a sample outline map of Kuwait. It was generated by requesting the VPFVIEW software to plot international borders, coastlines, oceans, and both a lat-long grid and scale bar. This is about as simple a plot as one can make. Figure 10 builds upon figure 9 and adds both Roads and Physiography to the map display. The final example figure 11 builds upon figure 10 but shows a larger area and

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[3]These themes and their specific features are presented in Appendix G of the VPFVIEW USERS MANUAL FOR THE DIGITAL CHART OF THE WORLD.

displays several Land Cover features.

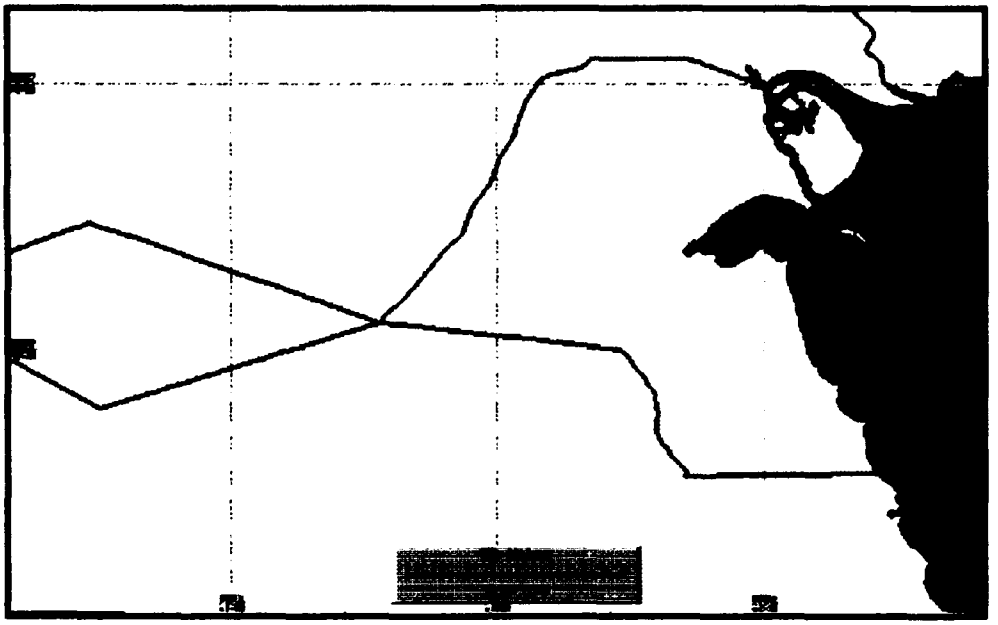

Figure 9 DCW Outline Map With Lat-Long Grid and Scale Bar

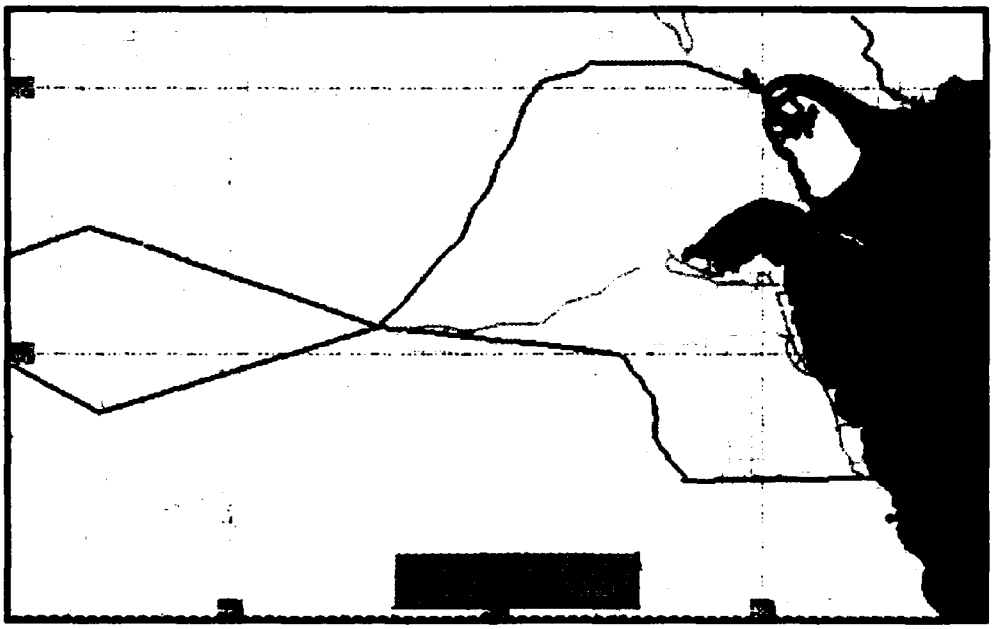

Figure 10 DCW Outline Map With Roads and Physiography

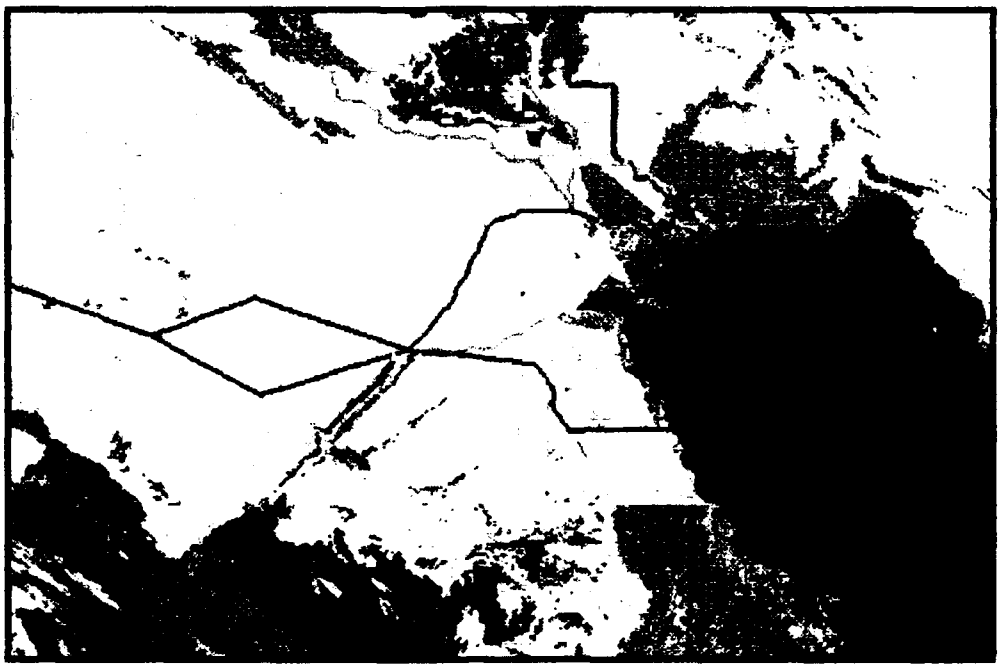

Figure 11 DCW Outline Map With Roads and Land Features

The VPFDUMP Utility Software

The DCW databases unlike the ADRG databases are composed of thematic information tables. These tables contain the information that the VPFVIEW software uses to generate its maps. The data that is contained in these tables may be viewed, printed, and/or captured in a file via the VPFDUMP program that is provided with the DCW product. VPFDUMP is a DOS executable that converts the database tables to ASCII screen output that may be piped to either a DOS file or a printer. We have verified that it works well although one should be aware of the large size of some of the database tables.

VISUAL BASIC DISPLAY MECHANISM FOR ADRG AND DCW MAPS

During the course of this study we experimented with MS-Visual Basic to see if we could easily display ADRG and DCW maps in a program. To our surprise we found that a no lines of code program could display either a .PCX or .BMP map generated from ADRG and VPFVIEW respectively. The trick is to assign the file name of the map that was generated from either of the DMA packages to a Visual Basic form's background picture attribute. This no line of code Visual Basic "program" can actually be compiled and executed. It will indeed display the map in all its original detail. One word of caution is to remember that Visual Basic only supports 16 colors so use the 16 color palette when

generating your map in ADRG or use a third party control such as that from MicroHelp to facilitate the display of 256 color bit maps.

FINDINGS

The Defense Mapping Agency's ADRG and DCW mapping products provide a robust set of features that can be readily used by almost anyone who has a DOS based PC with a CD-ROM player. The two products take very different approaches to map generation. The ADRG products actually store the original map(s) they are derived from as 24 bit RGB images at 100 micron resolution. The new DCW product, on the other hand, vectorizes the information contained on the original maps and stores that information in thematic tables. These DCW tables can then be processed to generate a variety of map styles. During the course of this study the value of both products became evident. The ADRG product clearly provides the best overall reproduction of the original maps. In its current form the DCW product captures much of the detail in the original map but it lacks the ability to reproduce the subtle hues and features of the original map. On the positive side the DCW product facilitates the production of a wide variety of thematic and feature specific maps that it is almost impossible to get from the ADRG digitized images.

Finally something should be said concerning the complexity of these products and their supporting software. Both the ADRG and VPFVIEW software are quite complex. The source code of each product is large and understanding it is not simple even though the code is well written. The ADRG and VPFVIEW executable programs have moderate learning curves. By this I mean that one can get reasonable results from the products rather quickly but subtle knowledge of how one fine tunes their outputs can take several days to a week. Unfortunately trial and error is probably the best teacher.

In summary these two products complement one another rather than compete with one another. The ADRG product produces maps that have the look and feel of the actual paper maps that they were derived from. The DCW product currently produces feature specific maps that appear more like line drawings when judged against the ADRG maps or actual ONC/JNC charts. This is a distinct benefit at time because it greatly facilitates the display of only that information that is of interest. In the future I suspect that the VPFVIEW software will become more sophisticated and will allow color palettes which can handle both more colors and be more closely matched to the ONC/JNC actual colors.

RECOMMENDATIONS

This study has found the ADRG and DCW products to be an excellent source of maps for use in both IDA publications and software. The following specific recommendations are made.

1) It is recommended that IDA obtain a complete set of ADRG CD-ROMs for its library along with a copy of the DCW product.

2) It is recommended that the library obtain any necessary PC hardware that will facilitate the use of these products in the library including color printing capability through 11 by 17 inches.

3) It is recommended that IDA programmers use the ADRG or DCW products as a standardized source of map information wherever possible.

4) It is recommended that IDA use the ADRG and DCW maps as standards in its publications. This would insure a consistent look to our published maps and provide an automatic archive of the maps used.

Appendix A
Mapping References Consulted

Map Projections-A Working Manual, John P. Snyder, USGS Professional Paper 1395, 1987

Supplement to Department of Defense World Geodetic System 1984 Technical Report: Parts 1, 2, and 3, DMA TR 8350.2A,B,C

View ADRG Software Architecture, DMA 600-88-D-0012, included on disk in addendum

A Graphics Device Survey for Running View ADRG in the WINDOWS 3.0 Environment, DMA 600-91-D-0001, included on disk in addendum.

View ADRG User Manual, DMA 600-88-D0012, included on disk in addendum.

MILITARY SPECIFICATION ARC DIGITIZED RASTER GRAPHICS (ADRG) MIL-A-89007

MILITARY STANDARD VECTOR PRODUCT FORMAT MIL-STD-600006

MILITARY SPECIFICATION DIGITAL CHART OF THE WORLD (DCW), MIL-D-89009

VPFVIEW 1.0 USERS MANUAL FOR THE DIGITAL CHART OF THE WORLD, DMA Stock No. DCWXXMANUAL